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# Implementing a Native XML Database

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## Two main files in database

❖ **Missions: Llist of space missions and the technological capabilities with associated metrics required/desired by each mission**

❖ **Technologies:  List of existing and proposed technologies, along with the capabilities they offer and associated metrics**

## Modest size requirements

❖ **No more than a few thousand records in each file**

## Handle hierarchical data well

❖ **Mission structures are hierarchical in nature**

## Easily modifiable structure

❖ **Requirements and technologies are ever-changing**

## Ease of Use

❖ **Data entry/modification, data extraction**

❖ **Documentation**

## Cross-platform access

❖ **Analysts may use their own computers to extract data**

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## Hierarchical database
❖ Better match for handling hierarchical data than relational DB

## Use web browser based interface
❖ Cross-platform and easier to user

## Standard protocols and interfaces
❖ Allows pieces to be replaced if needs change
❖ Cross-platform

## Use Java as the language
❖ Good support for client/server, XML, web interface

## XML Schema for schema description
❖ Turbo XML from TIBCO for schema design & modification

## XQuery for querying database
❖ Qexo is open source, but incomplete
❖ Looking for alternatives

## Data does not easily fit into tables

- ❖ No clean rows and columns
- ❖ Hierarchical in nature
- ❖ Poor match for relational database storage
- ❖ Would require large numbers of sparse tables

## Ideally suited for XML format

- ❖ High ratio of object types to number of objects

## Added XML bonus: suitability for Web use

- ❖ Many tools exist for display and manipulation of XML data

## Disadvantages

- ❖ XML data uses lots of storage space--tags are repeated for each entry
- ❖ Retrieval can be slow
- ❖ Memory based DB => upper size limit of 1-2 GB

Example--A mission capability such as Formation Flying can contain a number of optional systems, such as:

❖ Formation Initialization, Fine Formation Flying, Stop & Stare Formation Flying

Each of the above has its own set of optional systems.  Formation Initialization might require:

❖ Target Acquisition, Positioning, GN&C

GN&C might require some of the following subsystem capabilities:

❖ Collision/Constraint Avoidance, Fault Tolerance, Formation State Executive, Formation Executive, etc.

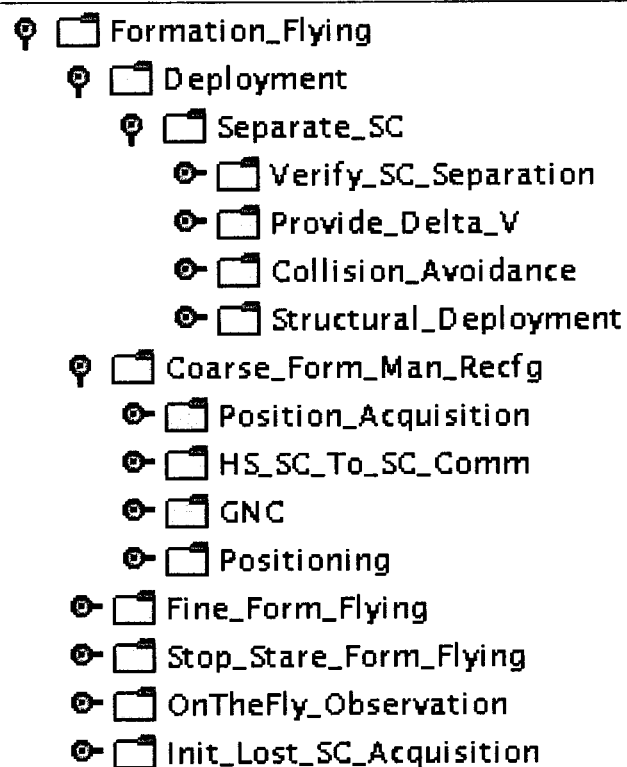Difference instances of GN&C require different sets of capabilities

These requirements are met more efficiently by a hierarchical structure than a tabular one

# Flat Display

**decomposition_v4_5.xls**

| | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | | | | | | | | | | | | | | | |
| 34 | **Mission Capabilities:** | | | | | | | | | | | | | | |
| 35 | 1. | Multiple Spacecraft Integration & Testing | | | | | | | 316.5 | | | 125 | | | |
| 36 | 2. | Launch, Cruise & Orbit Insertion | | | | | | | 316.5 | | | 125 | | | |
| 37 | 3. | Multiple Spacecraft Ground Control | | | | | | | 316.5 | | | 125 | | | |
| 38 | 4. | Spacecraft Infrastructure (Power, Thermal) | | | | | | | 316.5 | | | 125 | | | |
| 39 | 5. | Formation Flying | | | | | | | 256.2 | Y | | 125 | | | |
| 40 | | | | | | | | | | | | | | | |
| 41 | | | | | | | | | | | | | | | |
| 42 | | | | | | | | | | | | | | | |
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| 45 | | | | | | | | | | | | | | | |
| 46 | | | | | | | | | | | | | | | |
| 47 | | | | | | | | | | | | | | | |
| 48 | | | | | | | | | | | | | | | |
| 49 | 5.2.2.1. | | | | Acquire Relative Bearing | | | | 3.8 | | | 1 | Accuracy | 1 | degree |
| 50 | | | | | | | | | | | | 1 | Bearing Rate Knowledge | 10 | arcmin/s |
| 51 | 5.2.2.2. | | | | Acquire Relative Range | | | | 3.8 | | | 1 | Accuracy | 50 | cm |
| 52 | | | | | | | | | | | | | | | |
| 53 | | | | | | | | | | | | | | | |
| 54 | | | | | | | | | | | | | | | |
| 55 | 5.2.3.1. | | | | Collision/Constraint Avoidance | | | | 1.9 | | | 1 | # of Constraints | 25 | |
| 56 | | | | | | | | | | | | | Update Rate | 1 | Hz |
| 57 | 5.2.3.2. | | | | Fault Tolerance | | | | 1.9 | | | 1 | # of Monitors | 100 | |
| 58 | | | | | | | | | | | | | Update Rate | 1 | Hz |
| 59 | 5.2.3.3. | | | | Formation State Estimation | | | | 1.9 | | | 1 | #modes*#transitions*#S/C | 200 | |
| 60 | | | | | | | | | | | | | Update Rate | 1 | Hz |
| 61 | 5.2.3.4. | | | | Formation Executive | | | | 1.9 | | | 1 | # of funtions + # actuators | 100 | |
| 62 | | | | | | | | | | | | | Update Rate | 1 | Hz |
| 63 | | | | | | | | | | | | | | | |
| 64 | | | | | | | | | | | | | | | |
| 65 | | | | | | | | | | | | | | | |
| 66 | | | | | | | | | | | | | | | |
| 67 | | | | | | | | | | | | | | | |
| 68 | 5.3.1.1. | | | | Acquire Relative Bearing | | | | 3.8 | | | 1 | Field of Regard | 10 x 10 | degrees |
| 69 | | | | | | | | | | | | | Bearing Knowledge | 1.0 | degree |
| 70 | | | | | | | | | | | | | Bearing Rate Knowledge | 1.0 | arcmin/s |
| 71 | 5.3.1.2. | | | | Acquire Relative Range | | | | 3.8 | | | 1 | Operational Range | 16-100 | meters |
| 72 | | | | | | | | | | | | | Range Knowledge | 1.0 | meters |
| 73 | | | | | | | | | | | | | Range Rate Knowledge | 1.0 | cm/s |
| 74 | 5.3.1.3. | | | | Acquire Formation Attitude | | | | 3.8 | | | 1 | Accuracy | | |

Subsystems \ TPF / LISA / MMS / MagCon / Technology Values / Technology / References

Ready

CAPS NUM

# Hierarchical Display
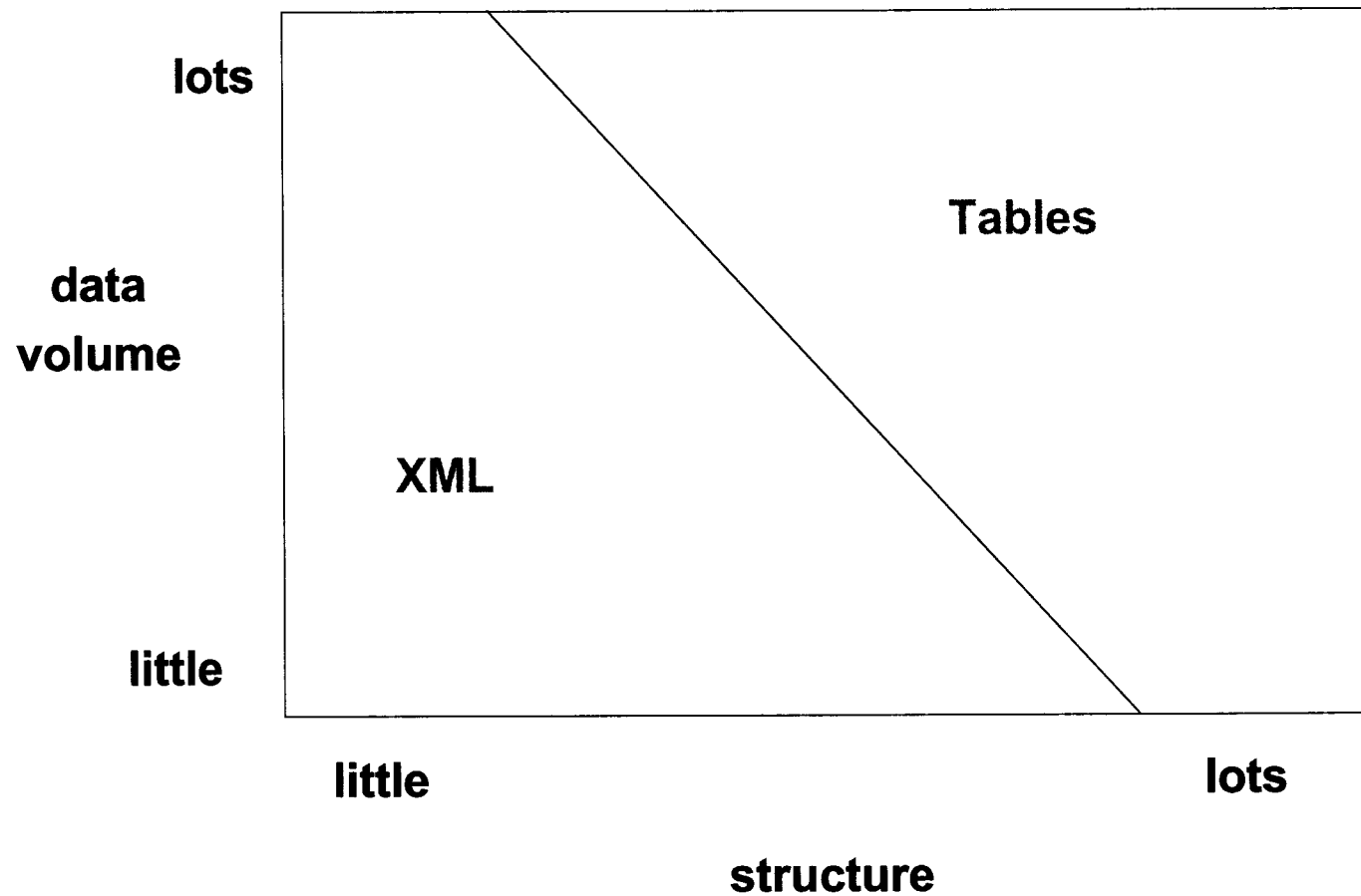
- 📁 Formation_Flying
  - 📁 Deployment
    - 📁 Separate_SC
      - 📁 Verify_SC_Separation
      - 📁 Provide_Delta_V
      - 📁 Collision_Avoidance
      - 📁 Structural_Deployment
    - 📁 Coarse_Form_Man_Recfg
      - 📁 Position_Acquisition
      - 📁 HS_SC_To_SC_Comm
      - 📁 GNC
      - 📁 Positioning
    - 📁 Fine_Form_Flying
    - 📁 Stop_Stare_Form_Flying
    - 📁 OnTheFly_Observation
    - 📁 Init_Lost_SC_Acquisition

## Turbo XML

• Design data structure (schema)

## XEdit

• Input data
• Add branches
• Modify data

**NMP Database**

**Mission File**

**Technology File**

**Reports**

## XEval

• Generate queries
• Maintain query library
• Query database
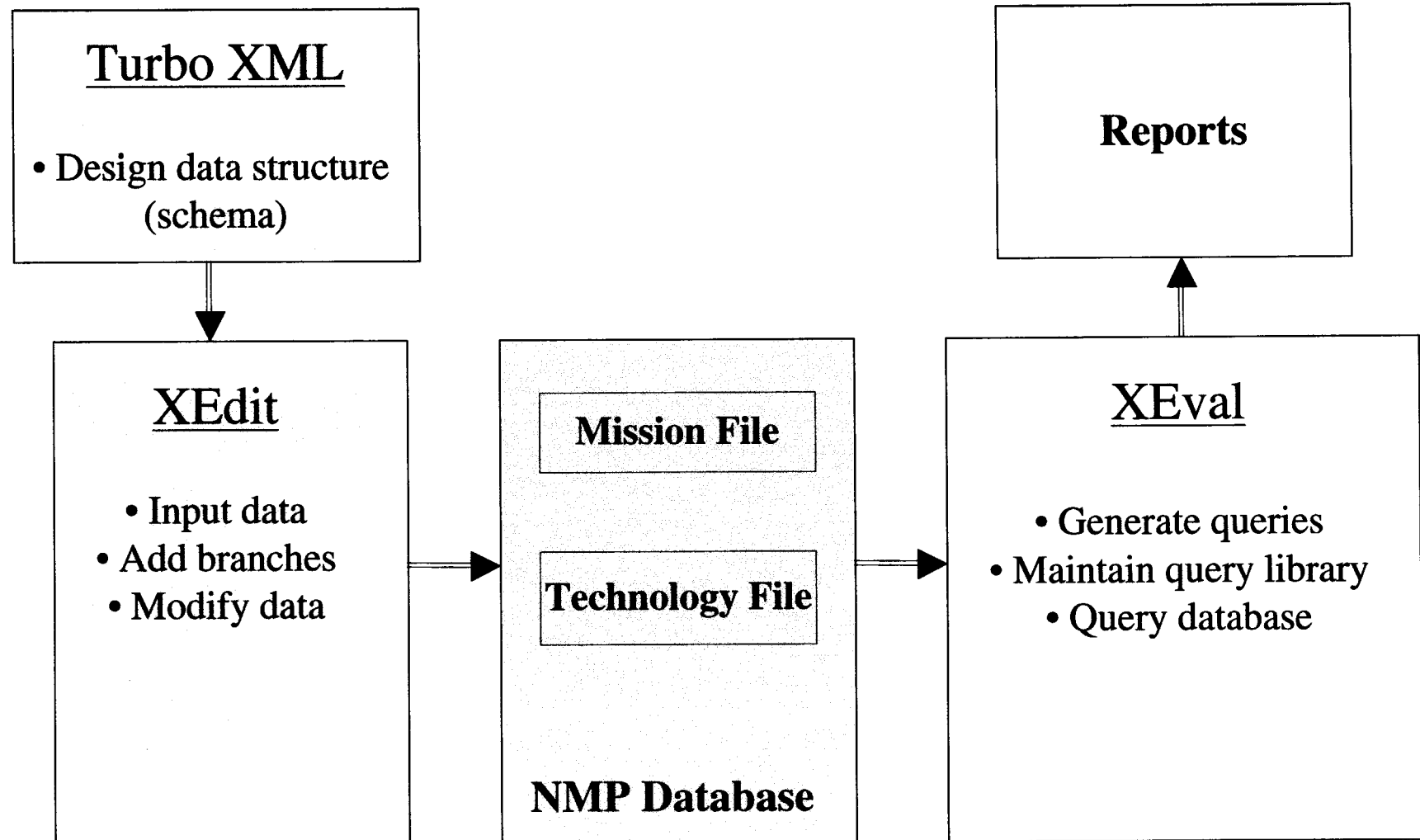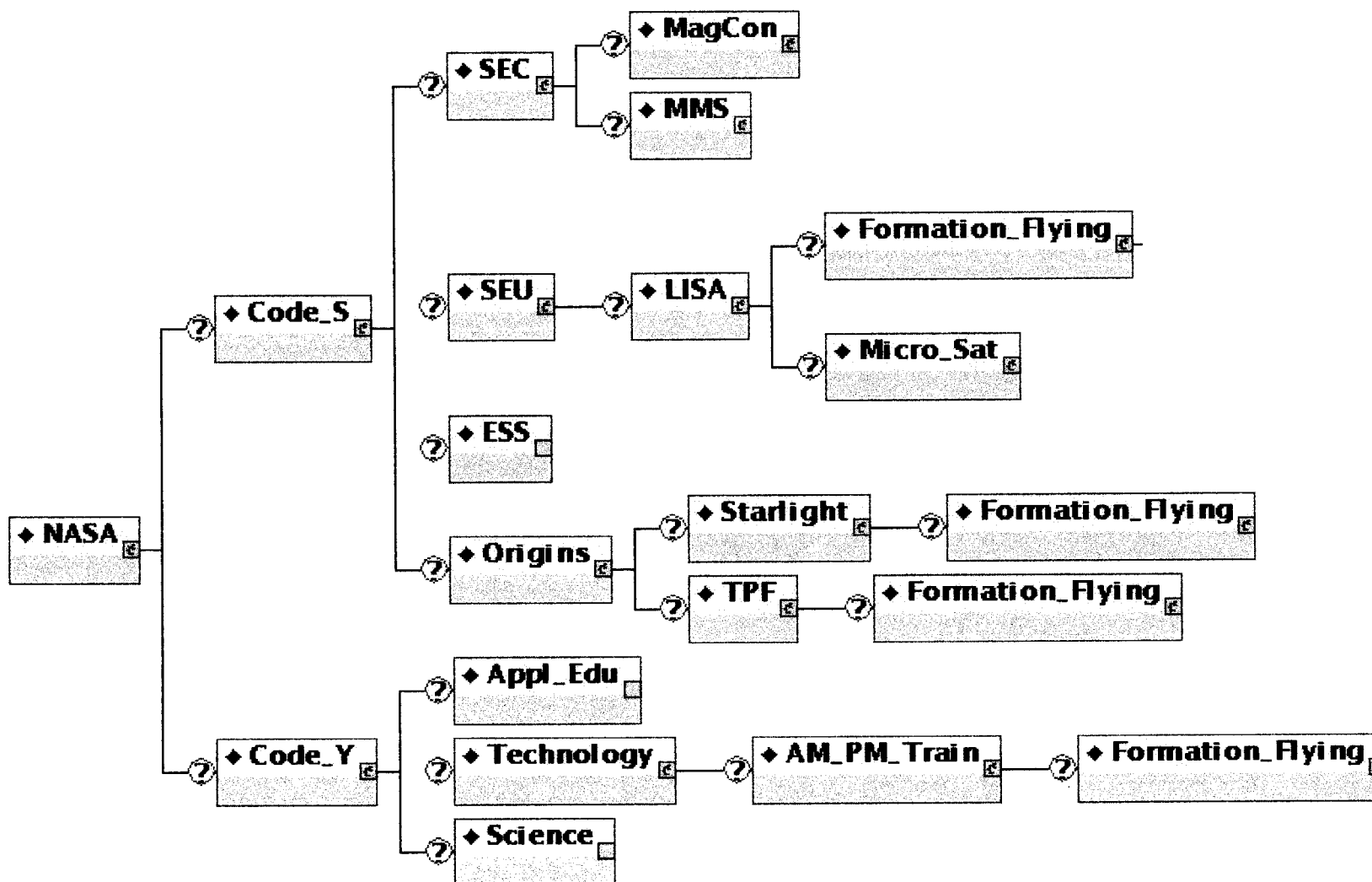
**Developed by this task to handle mission and technology data for NMP**

- ❖ **Changes to schema do not require XEdit modification**
- ❖ **Instead, new JAR files encapsulating schema information are generated by Castor**

  Castor is open source code that generates Java descriptor files for each XML element in the schema--used for data binding purposes
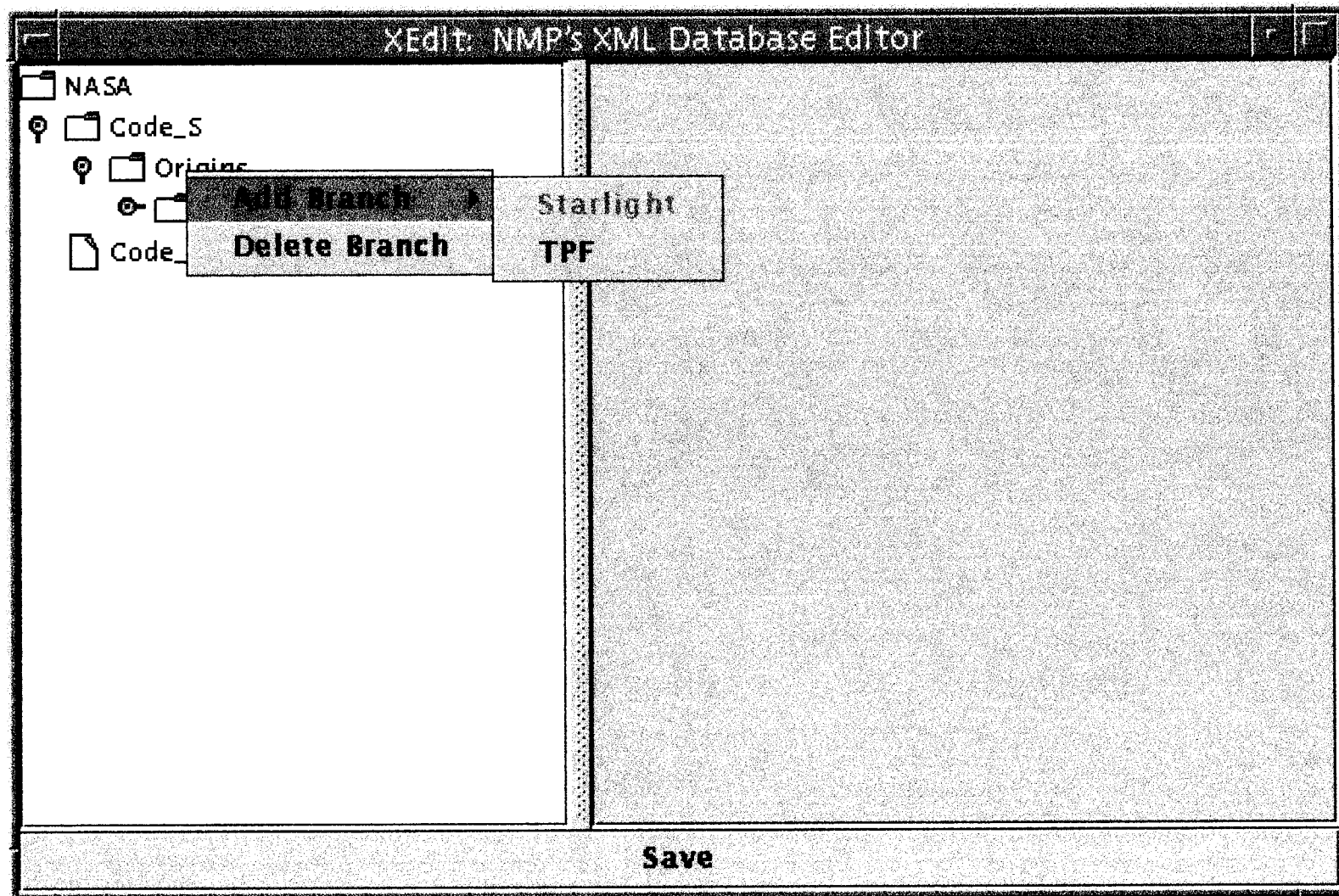
- ❖ **XEdit is then run with the new JAR files**

**Inputs data to database and allows hierarchy branches to be added or deleted**

- ❖ **Branch modification is controlled by information in the schema**

**Can enter data values or modify them**

# Adding and Deleting Branches

# Modifying Data Values

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| Tree | |
|---|---|
| NASA | |
| Code_S | |
| Origins | |
| Starlight | |
| Formation_Flying | |
| FF_Technology | |
| Relative_Nav | |
| Inertial_Nav | |
| Formation_Position_Control | |
| Formation_Attitude_Control | |
| Autonomous_Guidance | |
| Inter_SC_Comm | |
| Ground_Comm | |
| FF_Architecture | |
| Code_Y | |

| Property | Value |
|---|---|
| Range_Knowledge | 2 cm |
| Range_Rate_Knowledge | 0.0026 cm/s |
| RRK_Measurement_Duration | continuous |
| Operational_Range | 30–1000 m |
| Bearing_Knowledge | 0.0628 mrad |
| Bearing_Rate_Knowledge | $6.77 \times 10^{-5}$ mrad/s |
| BFK_Measurement_Duration | continuous |
| Field_of_Regard | 1.22 rad |
| Update_Frequency | 1 Hz |

Save

# Web based interface

❖ **Allows for form based customizable queries**

❖ **Accessible through any web browser**

❖ **Easy to navigate**

# Java Servlet backend

❖ **Processes HTML from posts**

❖ **Interfaces with Qexo (Xquery engine)**

❖ **Query results formatted in HTML**

# Fully customizable query editor is under development

## New Millennium Program
Developing and testing advanced technology in space flight.

NMPDB Queries

**Sample Query #1**

Find all missions that use capabilities addressed by "IRAS" technology

[ Execute Query ]

**Sample Query #2**
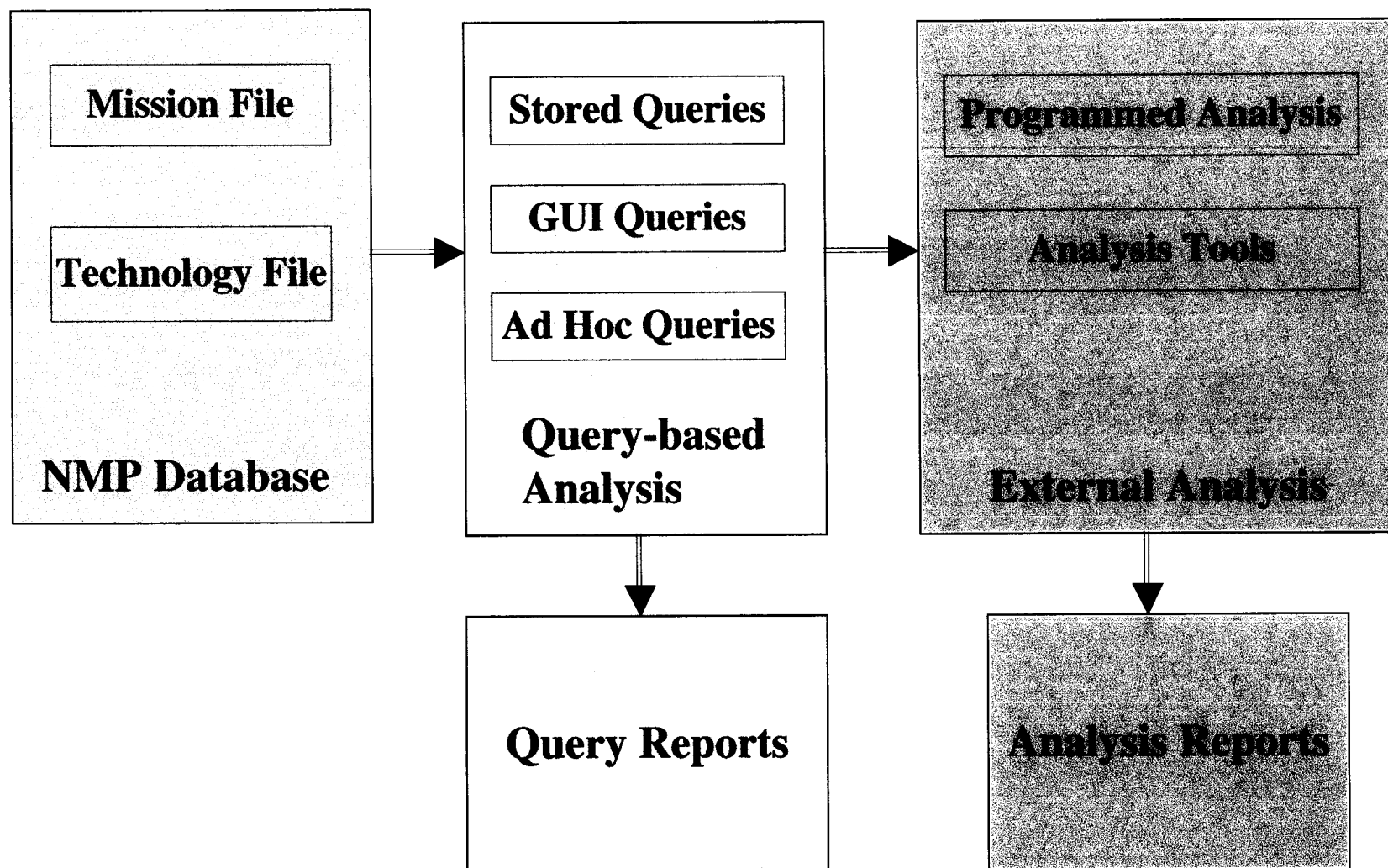
Find [ all ▾ ] Capabilities of Mission [ MagCon ▾ ]

[ Execute Query ]

**Sample Query #3**

Find all Technologies that address any Capability needed by mission [ MagCon ▾ ]

[ Execute Query ]

## Database server computer set up

## Software installed

- ❖ Mandrake Linux
- ❖ NetBeans for Java development
- ❖ TurboXML for schema development
- ❖ XML Transform for reorganizing database
- ❖ Castor for data binding
- ❖ Qexo for data querying

## First version of XEdit delivered

## Web based query interface demonstrated for sample queries

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Revise XEdit as needed

Improve database reorganization process

Purchase/modify/write database XML Query engine

Purchase/write GUI for query generation

Report generator
  ❖ Can export data to spreadsheets for further analysis

Implement multi-user capabilities
  ❖ Assign write privileges to only certain users

Hierarchical XML database matches structure of the data

Mix of commercial, open-source, and in-house software

Industry standards being used:  HTML, XML, XSchema, XQuery, Java Servlets

Have acquired or developed tools for schema generation, data entry and modification, data querying

Currently working on developing visual interface for data queries

# Acknowledgement

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